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ON THE MIGRATORY COURSE OF *TRICHOSOMOIDES CRASSICAUDA* (BELLINGHAM) IN THE BODY OF THE FINAL HOST*

SADAMU YOKOGAWA
Department of Pathology, Medical College of Formosa

Trichosomoides crassicauda, a nematode belonging to the family Trichinellidae, was found in the bladder of wild rats in 1845 by Bellingham. Hall (1916) has summed up the previous work on this species. This nematode is remarkable on account of the great difference in size between the males and females. The male is commonly found parasitic in the vagina or uterus of the female, having a length of 1.46 to 2.5 mm. and a width of 23 to 33μ. The female is 10.5 to 13 mm. long and attains a maximum width in the posterior region of the body of about 0.2 mm. Nothing is known of the method of infection of this parasite or its migratory course to the bladder of the rat. Von Linstow (1874) suggested that the embryos might bore into the wall of the digestive tract and make their way to the pelvis of the kidney by way of the renal artery. He described also that sexually immature individuals, the males but little smaller than the females, were found in the pelvis of the kidney and that copulation took place in the ureters. Later the females became larger and the males entered their vaginae. Hall (1916: 16) found that the embryos escaped from their shells in the vagina of the female after the worm had been in normal salt solution a short time. He suggested from this observation and from the fact that such embryos seemed to live only a short time that infection must take place in a rather short period as a rule, or else the embryos would perish. He also described that the embryos which had just escaped from the egg, had a body of almost uniform thickness, terminating in bluntly rounded ends, while von Linstow stated that they were provided anteriorly with a single lancet-like process.

I found some specimens of *Trichosomoides crassicauda* in wild rats *Epimys norvegicus,* collected near Baltimore during the winter of 1919-20. The parasites were usually found attached to the wall of the bladder with their anterior ends somewhat embedded in the mucous membrane. They cause a rather high degree of catarrhal cystitis according to the number of the parasites present. The mucous membrane of the bladder was found congested and swollen and the urine more or less muddy. The number of the parasites in the bladder of a single rat is commonly small, although sometimes ten or more specimens were found in a single host.

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* Contribution from the Department of Medical Zoology of the School of Hygiene and Public Health of the Johns Hopkins University.

In order to discover the method by which the rat is infested with *Trichosomoides crassicauda* I fed two white rats on January 20, 1920, with the eggs which contained the fully developed embryos. One of these rats became infected and the parasites developed to maturity. The eggs from the urine of this rat were used in later experiments. After the success of this experiment I undertook to investigate the migratory course of the larvae in reaching the bladder of the rat by feeding white rats with large numbers of the eggs of this parasite, and examining the various organs a short time after feeding. Three rats were used at different times but from only one of them were the larvae recovered. The results of this study are incomplete and a much larger series of experiments will be needed to clear up the details of the problem. However, some very definite information was obtained in regard to the migratory course of this parasite in the body of the final host. Since it will be impossible for me to continue these experiments I am writing up my results in hopes that some one else may use them in carrying on further work on this interesting problem.

Since the methods used with the three experimental rats were the same, I will describe here only the details of the work with the one rat which gave positive results.

On May 15 and 16, I fed one half grown white rat with many eggs of *Trichosomoides crassicauda* collected from the urine of the white rat experimentally infected with the parasite and of two wild rats which were infested naturally. The next day I fed it 15 adult worms containing many eggs in their uteri and also many eggs collected from the urine of the three rats mentioned above. On the following day also it was fed with many eggs collected from the urine of these rats. I killed this rat on May 19, one to four days after the various feedings.

The following technic was used in the recovery of the larvae from the body of the rat. First I opened carefully the abdominal cavity, avoiding bleeding, and washed it out several times with normal saline for the purpose of collecting any larvae contained in it. The liver and other internal organs were found to be a little congested without showing any bleeding points. Then I opened the pleural cavity in the same way and washed it out with normal saline. Both lungs were found to be a little congested showing some bleeding points on their surfaces. I examined one third of the liver, both kidneys, the spleen, and the left lung according to the following method. These internal organs were crushed into fine pieces and washed with normal saline two to four times, and filtered through a fine wire net. The filtrate from the different organs and wash water of abdominal and pleural cavities were kept carefully separate and were centrifuged to collect the larvae.

The following results were obtained from these examinations. Four larvae were found in the abdominal cavity, two in the pleural cavity, and three in the left lung. One third of the liver, both kidneys and the spleen were examined without finding any larvae, while the right lung and two thirds of the liver were preserved for later microscopical examinations. I also examined the ureters, bladder and heart, without finding any larvae. Comparing the structure of the young larvae found in the body cavity and in the lungs with larvae just escaped from the eggs, I learned the following facts. The larvae just from the eggs have a very small body of almost uniform thickness, terminating in bluntly rounded ends. They measure about 0.21 to 0.25 mm. in length and 8 to 10μ in thickness. It was impossible to make out any details of internal structure at this stage. The larvae found in the abdominal cavity of the experimental rat measured 0.82 to 0.84 mm. in length and 34 to 35μ in width. The anterior part of the body was a little thicker than the posterior end and ended bluntly. The digestive tract was not very clearly defined. The posterior end of the body was blunt with a diameter of about 0.02 mm. and had a small depression. The esophagus consisted of about twenty irregularly shaped cells. No esophageal cells were present for about 0.02 to 0.025 mm. at the anterior end. The esophagus was relatively long, measuring about 0.28 mm. The intestine ran straight along the middle body toward the posterior end and consisted of cells containing fine granules. The larvae found in the pleural cavity and two of the larvae found in the lungs were larger than those from the abdominal cavity. They were about 2.34 mm. long and 0.1 mm. thick. The anterior end was rounded and 0.03 mm. in diameter. The width increased toward the middle of the body with a maximum of 0.1 to 0.11 mm. and then decreased posteriad. The esophagus consisted of about twenty cells and measured about 0.54 mm. in length. No cells were present for a short distance at the anterior end. One larva found in the lung was smaller than the others found in the same location, having a similar size and structure to the larvae found in the abdominal cavity. It is very probable that the larger larvae are females and the smaller ones males.

From these experiments I learned the following facts (1) Infection with *Trichosomoides crassicauda* can be induced in the white rat by feeding the eggs of the parasite. (2) The adult worms found in the bladder of experimental animals are very few compared with the number of eggs swallowed. (3) The eggs swallowed by the final host hatch in the digestive tract and penetrate through its wall into the abdominal cavity. From here they travel into the pleural cavity probably through the diaphragm and penetrate into the lungs from their surfaces.

The passage of the larvae of *Trichosomoides crassicauda* into the lungs of the experimental rat is very interesting in relation to the recent work on the life history of *Ascaris lumbricoides* which proves that after hatching in the intestine of the final host the larval stages of this parasite must make their way to the lungs before they can complete their development. Yoshidi (1918) and Ransom and Foster (1920: 30) conclude that this phenomenon is of common occurrence in the life cycles of parasitic nematodes. Besides the hookworms, Strongyloides, *Ascaris lumbricoides, Ascaris suum* and *Belascaris marginata,* they note also that *Haemonchus contortus* from the sheep and *Ascaris anoura* from the python probably have a lung phase in their life cycles. Recently Neshi (1918) reports the finding of four larvae of *Trichuris depressiuscula* in the lungs of a dog twenty-one hours after experimental infection.

This observation and my finding the larvae of *Trichosomoides crassicauda* in the lungs of the experimental rat after feeding with the eggs add the family Trichinellidae to those in which this phenomenon occurs, and strengthens Ransom and Foster's hypothesis that parasitism of the lungs by nematodes is a more primitive condition than parasitism of the alimentary canal.

On the method of migration of the larvae of this nematode from the lungs to the bladder of the host there is little definite information. Von Linstow's (1874) finding young worms in the kidneys and ureters suggests that they make their way to the kidneys and then pass down the ureters to the bladder. How they make their way from the lungs to the kidney is still an unsolved question. Taking for granted that the migration to the lungs is a necessary phase of the life history of this parasite, there are three possible ways in which it might migrate from the lungs to the kidneys. (1) The larvae might make their way into the small branches of the pulmonary veins, be carried to the heart and then pass to the kidney along the aorta and renal arteries. (2) The larvae in the lungs might break into the air cells and, like the hookworm larvae, travel up the trachea and down the esophagus into the intestine. From here it would be necessary for them to make their way to the kidneys by way of the body cavity. (3) Finally the larvae in the lungs might make their way back into the pleural cavity, through the diaphragm and body cavity to the kidney. The course by the blood stream would seem to be very difficult if not impossible on account of the large size of the larvae and the fact that the renal artery is a small vessel which branches at right angles from the dorsal aorta. It is possible of course that the smaller type found might follow this course. It seems to me that the second course is the most probable, but the solution of this interesting problem must await future investigations. At any rate the passage to the kidney requires a prolonged and difficult migration. This may account for the difficulty of producing the infestation and why the number of worms found in the bladders of the wild rats is usually so few.

SUMMARY

1. The infestation of rats with the bladder nematode, *Trichosomoides crassicauda,* was accomplished by feeding the eggs.
2. The finding of larvae of this species in the body cavity, pleural cavity and lungs of an experimental rat fed with large numbers of eggs, suggests that in the life cycle of this species the larvae must pass to the lungs before they can establish themselves in their normal habitat.
3. This observation and other recent studies strengthen the view that migration to the lungs is a common phenomenon in the life cycle of nematodes.
4. How larvae reach the bladder from the lungs was not determined but they probably are not carried in the blood vessels.

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